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Being competent in the Japanese and English language, certify that to the best of my knowledge and belief the attached English translation is a true and faithful translation made by me of Japanese Patent Application No.07-159645 filed on June 26, 1995.

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(Title of the Invention) OPTICAL DISC, AND READING SYSTEM AND MANUFACTURING METHOD OF THE DISC

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(Document) SPECIFICATION

(Title of the Invention)

OPTICAL DISC, AND READING SYSTEM AND MANUFACTURING METHOD OF THE DISC

(Scope of Claims for Patent)

(Claim 1) A writable optical disc having an information writing track, and a guiding track for introducing a laser beam to the information writing track, characterized in that

the guiding track has prepit information recorded thereon, the prepit information includes at least address information of the optical disc.

(Claim 2) The optical disc according to claim 1 wherein the prepit information is recorded on the guiding track at a position where interference of adjacent guiding tracks with the prepit information is prevented.

(Claim 3) The optical disc according to claim 1 wherein the information writing track is a groove track, and the guiding track is a land track.

(Claim 4) A reading system for reading the prepit information recorded on the guiding track of the optical disc of claim 1 comprising:

a photodetector having two photodetecting elements divided by a first line optically parallel with a radial direction of the disc for detecting reflected light of a laser beam reflected from the information writing track, and

prepit information extracting means for extracting

prepit information recorded on the guiding track based on a difference signal between outputs of the divided two photodetecting elements.

(Claim 5) The reading system of the optical disc according to claim 4 wherein the photodetector is further divided by a second line optically parallel with a tangential direction of the information writing track of the optical disc, and the difference signal is obtained from an output of a pair of photodetecting elements positioned on an inside portion of the second line and an output of a pair of photodetecting elements positioned on an outside portion of the second line for producing a tracking error signal.

(Claim 6) A reading system for reading the prepit information recorded on the guiding track of the optical disc of claim 1 comprising:

a photodetector having two photodetecting elements divided by a line optically parallel with a tangential direction of the information writing track of the disc for detecting reflected light of a laser beam reflected from the information writing track, and

prepit information extracting means for extracting a prepit information recorded on the guiding track based on a difference signal between outputs of the divided two photodetecting elements.

(Claim 7) The reading system of the optical disc according to claim 6 wherein the tracking error signal is produced based on a low frequency component of the

difference signal.

(Claim 8) A reading system for reading the prepit information recorded on the guiding track of the optical disc of claim 1 comprising:

a first photodetector having two photodetecting elements divided by a first line optically parallel with a tangential direction of the information writing track of the disc for detecting reflected light of a first laser beam reflected from the information writing track,

a second photodetector having four photodetecting elements divided by a second line optically parallel with the tangential direction of the information writing track of the disc, and divided by a third line optically parallel with a radial direction of the disc for detecting reflected light of a second laser beam reflected from the guiding track,

first difference signal producing means for producing a first difference signal based on a difference between outputs of the divided two photodetecting elements of the first photodetector,

second difference signal producing means for producing a second difference signal based on a difference between outputs of a pair of photodetecting elements positioned at an inside portion and at an outside portion of the second line of the second photodetector,

third difference signal producing means for producing a third difference signal based on a

difference between outputs of a pair of photodetecting elements positioned on a portion at a reading forward direction side and at a reverse direction side to the reading forward direction of the third line of the second photodetector,

tracking error producing means for producing a tracking error signal based on the first difference signal and the second difference signal, and

prepit information extracting means for extracting prepit information on the guiding track based on the third difference signal.

(Claim 9) A reading system for reading the prepit information recorded on the guiding track of the optical disc of claim 1 comprising:

a photodetector having two photodetecting elements divided by a line optically parallel with a radial direction of the disc for detecting reflected light of a laser beam reflected from the information writing track,

prepit signal producing means for producing a difference signal as a first prepit signal, from outputs of the divided photodetecting elements,

added signal producing means for producing an added signal of outputs of the divided photodetecting elements,

groove pit cancel signal producing means for producing a groove pit cancel signal based on the added signal, and

prepit information extracting means for subtracting

the groove pit cancel signal from the first prepit signal to produce a second prepit signal without prepit information caused by the added signal, whereby the groove pit cancel signal producing means is operated for shaping a waveform of the adding signal such that the prepit information generated from the prepit information extracting means becomes zero under the condition that the information is written in the information writing track, while the prepit information is not written in the guiding track.

(Claim 10) A reading system for reading the prepit information recorded on the guiding track of the optical disc of claim 1 comprising:

a photodetector having two photodetecting elements divided by a line optically parallel with a radial direction of the disc for detecting reflected light of a laser beam reflected from the information writing track,

prepit signal producing means for producing a difference signal as a first prepit signal, from outputs of the divided photodetecting elements,

groove pit cancel signal producing means for producing a groove pit cancel signal based on a laser beam for writing information on the information writing track, and

prepit information extracting means for subtracting the groove pit cancel signal from the first prepit signal to produce a second prepit signal without prepit information caused by the writing laser beam, whereby

the groove pit cancel signal producing means is operated for shaping a waveform of the adding signal such that the prepit information generated from the prepit information extracting means becomes zero under the condition that the information is not written in the information writing track, while the prepit information is not written in the guiding track.

(Claim 11) A method for manufacturing a writable optical disc having an information writing groove, a guiding land, and prepit information recorded on the land, the method comprising steps of

performing a laser cutting to expose a resist coated on an original glass substrate by a laser beam modulated based on prepit information to be recorded on a land,

developing the exposed resist, thereby forming a land and prepits on the land,

performing electroforming to the developed glass substrate for producing a master stamper,

performing electroforming to the master stamper at even times for producing a sub stamper, and

replicating an optical disc by using the sub stamper.

(Detailed Description of the Invention)

(Field of Industrial Exploitation)

The present invention relates to a writable optical disc, and a reading system and a manufacturing method of the disc.

(Prior Arts)

In a writable optical disc, information such as a synchronizing signal and address information (hereinafter called prepit information) for searching a position on the disc is previously recorded by laser cutting at a preformat stage in a manufacturing process. As one of methods of the preformat of the prepit information, a track (groove or land) on which information is written by a user is wobbled. In another method, prepits are recorded on the track.

(Problems to be solved in the Invention)

However, in the former method by wobbling, the track itself is wobbled in a waveform in right and left by a wobbling signal. Therefore, the magnitude of the modulation by the wobbling signal is limited to a small degree. As a result, the C/N decreases. Furthermore, since the interference of the adjacent tracks at the wobbling must be considered, pitch between the tracks can not be reduced. Consequently, the writing capacity of the disc is limited.

In the latter method by prepits, since the prepits are recorded, the space for writing the information is reduced. Therefore, the available efficiency of the disc is low.

The present invention is provided for solving the aforementioned problems. A first object of the present invention for solving the aforementioned problems is to provide a writable disc in which the writing capacity of

the disc is increased.

A second object of the present invention is to provide a reading system of the disc which can be effectively read out written information.

A third object of the present invention is to provide a manufacturing method of the disc where the disc is efficiently manufactured.

(Steps to solve the Problems)

In order to achieve the first object, according to an optical disc of the present invention, there is provided a writable optical disc having an information writing track, and a guiding track for introducing a laser beam to the information writing track, characterized in that the guiding track has prepit information recorded thereon, the prepit information includes at least address information of the optical disc.

In order to ensurely read out the prepit information, the prepit information is preferably recorded on the guiding track at a position where interference of adjacent guiding tracks with the prepit information is prevented.

The information writing track is a groove track, and the guiding track is a land track.

In order to achieve the second object, in accordance with a first reading system of the present invention, a reading system for reading the prepit information recorded on the guiding track of the optical

disc comprises a photodetector having two photodetecting elements divided by a first line optically parallel with a radial direction of the disc for detecting reflected light of a laser beam reflected from the information writing track of the disc, and prepit information extracting means for extracting prepit information recorded on the guiding track based on a difference signal between outputs of the divided two photodetecting elements.

In accordance with a second reading system of the present invention according to the first reading system, the divided photodetector is further divided by a second line optically parallel with a tangential direction of the information writing track of the optical disc, and the difference signal is obtained from an output of a pair of photodetecting elements positioned on an inside portion of the second line and an output of a pair of photodetecting elements positioned on an outside portion of the second line for producing a tracking error signal.

In accordance with a third reading system of the present invention, a reading system for reading the prepit information recorded on the guiding track of the optical disc comprises a photodetector having two photodetecting elements divided by a line optically parallel with a tangential direction of the information writing track of the disc for detecting reflected light of a laser beam reflected from the information writing

track, and prepit information extracting means for extracting a prepit information recorded on the guiding track based on a difference signal between outputs of the divided two photodetecting elements.

In accordance with a fourth reading system of the present invention according to the third reading system, the tracking error signal is produced based on a low frequency component of the difference signal.

In accordance with a fifth reading system of the present invention, a reading system for reading the prepit information recorded on the guiding track of the optical disc comprises a first photodetector having two photodetecting elements divided by a first line optically parallel with a tangential direction of the information writing track of the disc for detecting reflected light of a first laser beam reflected from the information writing track, a second photodetector having four photodetecting elements divided by a second line optically parallel with the tangential direction of the information writing track of the disc, and divided by a third line optically parallel with a radial direction of the disc for detecting reflected light of a second laser beam reflected from the guiding track, first difference signal producing means for producing a first difference signal based on a difference between outputs of the divided two photodetecting elements of the first photodetector, second difference signal producing means for producing a second difference signal based on a

difference between outputs of a pair of photodetecting elements positioned at an inside portion and at an outside portion of the second line of the second photodetector, third difference signal producing means for producing a third difference signal based on a difference between outputs of a pair of photodetecting elements positioned on a portion at a reading forward direction side and at a reverse direction side to the reading forward direction of the third line of the second photodetector, tracking error producing means for producing a tracking error signal based on the first difference signal and the second difference signal, and prepit information extracting means for extracting prepit information on the guiding track based on the third difference signal.

In accordance with a sixth reading system of the present invention, a reading system for reading the prepit information recorded on the guiding track of the optical disc comprises a photodetector having two photodetecting elements divided by a line optically parallel with a radial direction of the disc for detecting reflected light of a laser beam reflected from the information writing track, prepit signal producing means for producing a difference signal as a first prepit signal, from outputs of the divided photodetecting elements, added signal producing means for producing an added signal of outputs of the divided photodetecting elements, groove pit cancel signal

producing means for producing a groove pit cancel signal based on the added signal, and prepit information extracting means for subtracting the groove pit cancel signal from the first prepit signal to produce a second prepit signal without prepit information caused by the added signal, whereby the groove pit cancel signal producing means is operated for shaping a waveform of the adding signal such that the prepit information generated from the prepit information extracting means becomes zero under the condition that the information is written in the information writing track, while the prepit information is not written in the guiding track.

In accordance with a seventh reading system of the present invention, a reading system for reading the prepit information recorded on the guiding track of the optical disc comprises a photodetector having two photodetecting elements divided by a line optically parallel with a radial direction of the disc for detecting reflected light of a laser beam reflected from the information writing track, prepit signal producing means for producing a difference signal as a first prepit signal, from outputs of the divided photodetecting elements, groove pit cancel signal producing means for producing a groove pit cancel signal based on a laser beam for writing information on the information writing track, and prepit information extracting means for subtracting the groove pit cancel signal from the first prepit signal to produce a second

prepit signal without prepit information caused by the writing laser beam, whereby the groove pit cancel signal producing means is operated for shaping a waveform of the adding signal such that the prepit information generated from the prepit information extracting means becomes zero under the condition that the information is not written in the information writing track, while the prepit information is not written in the guiding track.

In order to achieve the third object, according to a manufacturing method of the optical disc of the present invention, there is provided a method for manufacturing a writable optical disc having an information writing groove, a guiding land, and prepit information recorded on the land, the method comprising steps of performing a laser cutting to expose a resist coated on an original glass substrate by a laser beam modulated based on prepit information to be recorded on a land, developing the exposed resist, thereby forming a land and prepits on the land, performing electroforming to the developed glass substrate for producing a master stamper, performing electroforming to the master stamper at even times for producing a sub stamper, and replicating an optical disc by using the sub stamper.

(Function)

In accordance with the optical disc of the present invention, the prepit information including address information is recorded on the guiding track. Thus, the capacity for writing the information is increased.

If the prepit information is recorded on every other land, the prepits on the adjacent lands opposite to the groove are not interfered from each other.

If the groove is used as the information writing track, and the land is used as the guiding track, the recorded information and the prepit information can be ensurely and separately read out.

In accordance with the first reading system of the present invention, the prepit information for guiding track is derived based on the difference signal between the outputs produced from the two-divided photodetector.

In accordance with the second reading system of the present invention, the prepit signal and the tracking signal are obtained by the single photodetector.

In accordance with the third reading system of the present invention, the prepit information for guiding track is derived based on the difference signal between the outputs produced from the two-divided photodetector divided in the track direction.

In accordance with the forth reading system of the present invention, the tracking signal is produced by the difference signal at a low frequency area.

In accordance with the fifth reading system of the present invention, the prepit information and the tracking information are obtained by two photodetectors.

In accordance with the sixth reading system of the present invention, the groove pit cancel signal is produced using the outputs of the four-divided

photodetector for canceling noises caused by the written information.

In accordance with the seventh reading system of the present invention, the groove pit cancel signal is produced by the modulating signal for modulating the laser beam. Thus, noises caused by the written information is canceled.

In accordance with the manufacturing method of the optical disc of the present invention, since the original substrate is cut by one cutting process, the prepit on the land is not deflected, thereby manufacturing the disc of a high quality.

(Preferred Embodiments)

An embodiment of the present invention will be described hereinafter. Fig. 1 is an enlarged perspective view partly showing grooves and lands of an optical disc (hereinafter called disc) according to the present invention, and Fig. 2 is schematic diagrams showing examples of prepits formed on lands of the disc.

Referring to Fig. 1, an optical disc 1 comprises a transparent layer made of transparent resin such as polycarbonate. On the underside of the transparent layer, a plurality of grooves 2 as information writing tracks, and a land 3 as a guiding track are spirally formed from a central portion of the disc to an outer periphery thereof. Prepits 4 are recorded on the land 3 as the guiding track for prepit information by the preformat.

Fig. 1 typically shows the optical disc of the present invention. A metallic reflection film 5 is coated on the underside of the grooves 2 and the lands 3. A protection film (not shown) is layered on the underside of the reflection film 5. In Fig. 1, a laser beam for recording and reproducing is projected from a portion above the disc 1 to the groove 2 and the land 3.

In the embodiment, the prepits 4 are recorded on every other land 3 for preventing the prepit information from interfering as shown in Fig. 2(A). The reason why the prepits are recorded on every other land is as follows. Namely, when writing or reproducing the information by a pickup, if the prepits 4 are recorded on each of the lands 3, the pickup may read information of prepits 4 recorded on adjacent lands which are disposed opposite sides of the groove 2 at the same time. Accordingly, the prepit information can not be ensurely reproduced.

Fig. 2(B) show another example of tracks for preventing the interference of the information. A recording pattern comprising an EVEN (even) pattern and an ODD (Odd) pattern is provided for recording the prepit information on the land. The prepit information is recorded by using two patterns.

Each of the EVEN and ODD patterns has sync Sy and ID information necessary for servo. The sync Sy and ID information recorded by the first pattern are deflected with a predetermined phase difference, for example, with

180 phase difference from the sync Sy and ID information recorded by the second pattern. The prepit information is first recorded in the spiral direction by the EVEN pattern. If the sync Sy and the ID of the adjacent lands are almost overlapped, the EVEN pattern is changed to the ODD pattern to continue recording. Then, if the sync Sy and the ID of the adjacent lands of the ODD pattern are almost overlapped, the EVEN pattern is used again.

Fig. 3 shows the manufacturing process of the disc. In a conventional disc, a prepit is recorded on a groove. In cutting of an original glass substrate, a groove is formed by laser cutting. If the conventional disc is employed for the present invention, the prepit is cut on a land after the groove is cut. Accordingly, the number of processes increases, and it is difficult to precisely cut the prepit.

In the present invention, when a laser cutting is performed, a resist coated on an original glass substrate is exposed by laser cutting and developed based on the prepit information, thereby forming lands and recording prepits on the lands at the same time. Thus, a master stamper is made. The master stamper is processed by electroforming to form a sub master, or the sub master is further processed by electroforming at even times to form a sub stamper. After the electroforming, a replication is made to the transparent layer. In the process, since the substrate is cut by

only one cutting process, the prepit is not deflected from the land. Thus, a disc having high accuracy can be manufactured.

Fig. 4 shows a cutting machine employed with the laser cutting.

The cutting machine comprises a laser 10 for emitting a laser beam having a large power. An optical modulator 11 is provided for modulating the laser beam from the laser 10 in accordance with land cutting information applied from an encoder 12. The laser beam modulated by the modulator 11 is focused on a resist 15 coated on a glass substrate 14 by an objective lens 13 for forming a spot thereon.

The glass substrate 14 is mounted on a spindle motor 16. The spindle motor 16 is rotated by a rotation detector 17 and a rotation servo circuit 18 at a constant linear velocity (CLV). The motor 16 is mounted on a feeding unit 19 to be moved in a radial direction of the glass substrate 14 by a position detector 20 and a feeding servo circuit 21 at a predetermined speed. Thus, the lands and prepits are cut on resist of the substrate 14 in a spiral direction from a central portion of the substrate to an outer periphery thereof.

Fig. 5 shows an embodiment of a reading system for reading information written on the disc as a first embodiment.

A laser beam for reproducing information is reflected from a prism 32 and projected on a recording

surface of the disc 1 through an objective lens 31 to form a spot of the laser beam. The light reflected from the disc 1 is fed to a photodetector 33 through the prism 32.

In the embodiment, the photodetector 33 comprises four-divided photodetecting elements A, B, C and D. The divided four elements A to D produce corresponding output signals (hereinafter called A to D to be easily understood) which are added and subtracted so that an RF signal, a tracking error signal, and prepit information recorded on the land are read out. Numerals 34 to 37 designate amplifiers connected to the photodetecting elements A to D, respectively. Numerals 38 to 43 and 47 are adders and subtracters.

The relationship between the photodetector 33 applied with the laser reflected from the disc 1, and the grooves 2 and lands 3 on the disc 1 is shown by the enlarged diagram P. In order to read the information written on the groove 2, all of the outputs A to D are added. In the embodiment, the output (A+D) added by the adder 40 and the output (B+C) added by the adder 41 are added by the adder 43. Thus, the RF signal (A+B+C+D) is produced from a terminal 46.

The tracking error signal is obtained by a difference between the outputs (A+D) and (B+C) divided in the tracking direction of the groove 2. In this state, the difference of a primary light, not a zero level light, is obtained. The output (A+D) of the adder

40 and the output (B+C) of the adder 41 are subtracted by the subtracter 42. Thus, the tracking error signal (A+D)-(B+C) is produced from a terminal 45.

The prepit information signal written on the land 3 is obtained by a difference between outputs (A+B) and (C+D) divided in the radial direction of the disc. In this state, the difference of a primary light, not a zero level light, is obtained. The output (A+B) added by the adder 38 and the output (C+D) added by the adder 39 are subtracted by the subtracter 47. Thus, the prepit signal (A+B)-(C+D) is produced from a terminal 44.

As will be seen from the relationship shown in the enlarged diagram P, since the prepits 4 are recorded on every other land 3, it is possible to read out information on the prepits 4. If the prepits 4 are recorded on each of the lands 3, the pickup may read information of prepits 4 recorded on adjacent lands which are disposed opposite sides of the groove 2 at the same time. Accordingly, the prepit information can not be ensurely reproduced. In the embodiment, the prepits 4 are recorded on every other land 3, thereby preventing the prepit information from interfering.

As a result, as shown in Fig. 2, when the disc makes one turn, one tracking finishes, the position of the lands 3 changes from the left (right) to the right (left) of the groove 2. However, the change of the position can be easily detected because polarity of the

prepit signal (A+B)-(C+D) produced from the terminal 44 is inverted.

Fig. 6 shows signals read out by the reading system.

From the foregoing, it will be seen that RF, tracking error and prepit signals are sufficiently and exactly read out. The prepit signal does not affect the RF signal, because the depth of the groove of the track is determined as shown in Fig. 7.

Fig. 8 shows a second embodiment of the reading system according to the present invention.

The second embodiment is employed with a three spot method. Three laser beams are projected on the disc 1 to form three spots 51, 52 and 53. The reading system has three photodetectors 54, 55 and 56 for detecting the respective spots 51, 52, 53, and a plurality of adders and subtracters 57 to 72, and a coefficient multiplier 73.

In the embodiment, in order to obtain the RF signal, an output (F+H) added by the adder 68 and an output (E+G) added by the adder 69 are added by the adder 71. Thus, the RF signal (E+F+G+H) is produced from a terminal 75.

In order to obtain a focus error signal, a focus error is detected by an astigmatism method using a cylindrical lens (not shown). The output (F+H) of the adder 68 and the output (E+G) of the adder 69 are subtracted by the subtracter 72. Thus, the focus error

signal (F+H)-(E+G) is produced from a terminal 76.

In order to obtain the prepit signal, the output (A+B) added by the adder 57 and the output (C+D) added by the adder 58 are subtracted by the subtracter 64. Thus, the prepit signal (A+B)-(C+D) is produced from a terminal 73.

The tracking error signal is obtained as follows.

An output (F+G) added by the adder 61 and an output (E+H) added by the adder 62 are subtracted by the subtracter 66. The output (F+G)-(E+H) is applied to a plus terminal of the subtracter 70. On the other hand, an output (B+C) added by the adder 59 and an output (A+D) added by the adder 60 are subtracted by the subtracter 65. The output (B+C)-(A+D) is applied to one of the terminals of the adder 67. Furthermore, an output (I+J) added by the adder 63 is applied to the other terminal of the adder 67. The output {(B+C)-(A+D)} +{(I+J)} of the adder 67 is multiplied by a constant K (K=0-1) for correction. The multiplied output K[{(B+C)-(A+D)}+{(I+J)}] is applied to a minus terminal of the subtracter 70.

Thus, the tracking error signal {(F+G)-(E+H)}-{(A+D)}-K[{(B+C)-(A+D)}+{(I+J)}] is produced from a terminal 73. In the embodiment, if the constant K is properly adjusted, noise signal caused by the prepit 4 on the land 3 included in the original tracking error signal (F+G)-(E+H) is reduced.

Fig. 9 shows a third embodiment of the reading

system of the present invention.

The system is provided for reducing influence of the information, even if the information is written on the groove with the prepit signal as much as possible, thereby obtaining the prepit signal with a good C/N.

In the embodiment, a photodetector 80 has four-divided photodetecting elements. Although in this embodiment, the four-divided photodetecting elements are used in order to obtain an RF signal and a tracking signal also, a photodetector having two-divided photodetecting elements may be used, in order to read only the prepit signal.

In this embodiment, the prepit signal is obtained as follows.

An inherent prepit signal (A+B)-(C+D) is obtained by a subtracter 81 using outputs A to D of the photo-detector 80. In the prepit signal (A+B)-(C+D), noises due to pit information written on the groove 2 are included.

In order to cancel the noises, the system has a waveform shaping circuit 82 for producing a groove pit cancel signal by using outputs A to D of the photo-detector 80. The groove pit cancel signal is applied to a subtracter 83 where the groove pit cancel signal is subtracted from the prepit signal (A+B)-(C+D). Thus, the noises are canceled.

A method for producing the groove pit cancel signal in the waveform shaping circuit 82 will be described

with reference to Fig. 10. It is assumed that no prepit is recorded on the land of the disc and that the information is written on the groove. When the beam spot is tracking on the groove of the disc, the added outputs (A+B) and (C+D) are shown by the waveforms (A) and (B) of Fig. 10, respectively.

On the other hand, the prepit signal (push-pull signal) is obtained by the calculation (A+B)-(C+D). If the calculation is made, the waveform (F) of Fig. 10 is produced. The output is noise to be included in the prepit signal if prepits are recorded on the land. Accordingly, if the noises are canceled from the prepit signal, the influence with the prepit signal is removed.

In the embodiment, the output (A+B+C+D) shown by the waveform (C) of Fig. 10 is produced by the outputs shown by the waveforms (A) and (B) of Fig. 10. The output is differentiated to produce a differential signal (D) of Fig. 10. Based on the differential signal, the groove pit cancel signal having the waveform (E) of Fig. 10 is produced.

It will be seen that the groove pit cancel signals (E) and the noise (F) of Fig. 10 have the same waveform. Thus, the noise cancel signal is subtracted from the prepit signal (A+B)-(C+D), which is obtained from the prepit on the land, by the subtracter 83 of Fig. 9, so that the influence of the written information is removed from the prepit signal as shown by the waveform (G) of Fig. 10, thereby obtaining the prepit signal having a

good C/N.

Fig. 11 shows a fourth embodiment of the reading system of the present invention.

In the embodiment, the prepit information recorded on the land is exactly read out while information is written in the groove of the disc. Although in the embodiment, a photodetector 90 having four-divided photodetecting elements are used, a photodetector having two-divided photodetecting elements may be used, in order to read only the prepit signal, similar to the third embodiment.

The reading system comprises the photodetector 90, a subtracter 91, a modulator 92 for modulating the laser beam, a laser 93 for emitting the laser beam, a prism 94, an objective lens 95, and a waveform shaping circuit 96. The laser beam emitted from the laser 93 is projected on the disc 1 through the prism 94 and the objective lens 95.

Fig. 12 shows the power of the laser for writing the information on the disc. When the information is read out, the laser power is controlled to be decreased, not to a zero level, so as to read the prepit information on the land even if the information is not written on the groove.

In the embodiment, the prepit signal is obtained as follows.

An inherent prepit signal (A+B)-(C+D) is obtained by the outputs A to D of the photo-detector 80. In the

is delayed by a time t to produce a delay signal having the waveform (D) of Fig. 13. The delay signal is shortened by the time t at the rear end so that a groove pit cancel signal having the waveform (E) of Fig. 13 is produced.

It will be seen that the groove pit cancel signal (E) and the noise (F) of Fig. 13 have the same waveform. Thus, the groove pit cancel signal is subtracted from the prepit signal (A+B)-(C+D) obtained by recorded prepit information by the subtracter 91 of Fig. 11, so that the influence of the noise is removed from the prepit signal, thereby obtaining a prepit signal having a good C/N.

In the embodiments, the push-pull signal is formed by a pair of outputs disposed on the opposite sides in the tracking direction. Alternatively, the push-pull signal may be formed by a pair of outputs of photo-detectors disposed on opposite sides of the track direction. In such a push-pull signal, tracking error signal and prepit signal are included. The tracking error signal is included in the push-pull signal as a low frequency component. The low frequency band of the tracking error signal is easily separated by using a filter.

It is possible to determine a left prepit or a right prepit of the groove by a polarity.

The embodiment of the present invention can be variously modified.

prepit signal (A+B)-(C+D), noises due to pit information written on the groove 2 are included.

The waveform shaping circuit 96 produces a groove pit cancel signal for canceling the noises in accordance with the modulating signal for modulating the laser power of the laser 93 from the modulator 92. The groove pit cancel signal is subtracted from the prepit signal (A+B)-(C+D) by the subtracter 91. Thus, the noises are canceled.

A method for producing the noise cancel signal in the waveform shaping circuit 96 will be described with reference to Fig. 13. It is assumed that no prepit is recorded on the land. The laser beam having a waveform (A) of Fig. 13 for writing information on the groove is reflected from the disc and received by the photodetector 90. The added outputs (A+B) and (C+D) of the photodetector 90 are shown by waveforms (B) and (C) of Fig. 13, respectively. In each of the waveforms (B) and (C) of Fig. 13, a pit written on the groove is represented at a position where the output is decreased stepwise.

On the other hand, if the prepit signal calculation (A+B)-(C+D) is made, a waveform (F) of Fig. 13 is produced. The output is noise to be included in a prepit signal produced by prepit information recorded on the land. Accordingly, if the noise is canceled, the influence on the prepit signal is removed.

In the embodiment, the writing light (A) of Fig. 13

(Effect of the Invention)

In accordance with the optical disc according to claim 1, the prepit information including address information is recorded on the land as the guiding track. Thus, the capacity for writing the information is increased, thereby improving the available efficiency of the disc.

In accordance with the optical disc according to claim 2, the prepit information is recorded on every other land. Thus, the prepits on the adjacent lands opposite to the groove are not interfered from each other. Thus, the prepit information with a good C/N can be obtained.

In accordance with the optical disc according to claim 3, the groove is used as the information writing track, and the land is used as the guiding track. Consequently, the recorded information and the prepit information can be ensurely and separately read out.

In accordance with the reading system according to claim 4, the prepit information for guiding track is derived based on the difference signal between the outputs produced from the two-divided photodetector. The prepit information is ensurely obtained with a simple structure.

In accordance with the reading system according to claim 5, the prepit signal and the tracking signal are obtained by the single photodetector. Thus, the system is reduced in size.

In accordance with the reading system according to claim 6, the prepit information for guiding track is derived based on the difference signal between the outputs produced from the two-divided photodetector divided in the track direction.

In accordance with the reading system according to claim 7, the tracking signal is produced by the difference signal at a low frequency area.

In accordance with the reading system according to claim 8, the prepit information and the tracking information are obtained by two photodetectors. Thus, the C/N is further improved.

In accordance with the reading system according to claim 9, in the disc having the written information, the groove pit cancel signal is produced for canceling noises caused by the written information. Thus, the prepit signal having a good C/N is obtained.

In accordance with the reading system according to claim 10, the groove pit cancel signal is produced by the modulating signal for modulating the laser beam, thereby canceling noises caused by the written information. Thus, the prepit signal having a good C/N is obtained.

In accordance with the manufacturing method of the optical disc according to claim 11,
a resist coated on an original glass substrate is exposed by laser cutting and developed based on the prepit information written on the land, thereby forming

a master stamper. The master stamper is processed by electroforming to form a sub master, or the sub master is further processed by electroforming at even times to form a sub stamper. Thereafter, a replication is made to the transparent layer. Since the original substrate is cut by one cutting process, the prepit on the land is not deflected, thereby manufacturing the disc of a high quality.

(Brief Description of Drawings)

Fig. 1 is an enlarged perspective view partly showing grooves and lands of an optical disc according to the present invention;

Fig. 2 is schematic diagrams showing examples of prepits formed on the disc;

Fig. 3 is a diagram showing a manufacturing process of the disc;

Fig. 4 is a diagram showing a cutting machine of the disc using a laser beam;

Fig. 5 is diagrams showing a reading system to which the present invention is applied;

Fig. 6 is a diagram showing signals read out by the reading system with respect to the conditions of the disc;

Fig. 7 is a diagram showing output characteristics of a push-pull signal and an RF signal with respect to depth of a groove;

Fig. 8 is diagrams showing a reading system of a second embodiment of the present invention;

Fig. 9 is diagrams showing a reading system of a third embodiment of the present invention;

Fig. 10 is an explanatory diagram showing signals for producing a groove pit canceling signal of the third embodiment;

Fig. 11 is diagrams showing a reading system of a fourth embodiment of the present invention;

Fig. 12 is a diagram showing power of a laser beam; and

Fig. 13 is an explanatory diagram showing signals for producing a groove pit canceling signal of the fourth embodiment.

(Description of Reference Numerals)

1 disc, 2 grove, 3 land, 4 prepit 5 reflection film, 33 photodetector 51-53 beam spot, 73 coefficient multiplier, 80 photodetector, 82 waveform shaping circuit 83 substracter, 90 photodetector, 91 subtracter 92 modulator, 96 waveform shaping circuit.

(Document) DRAWING

FIG.1

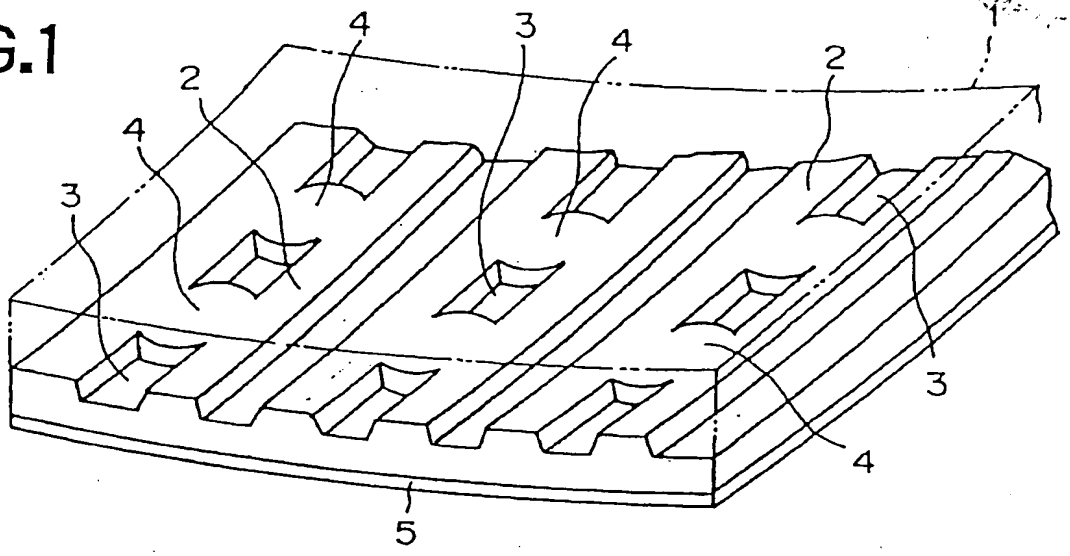


FIG.2

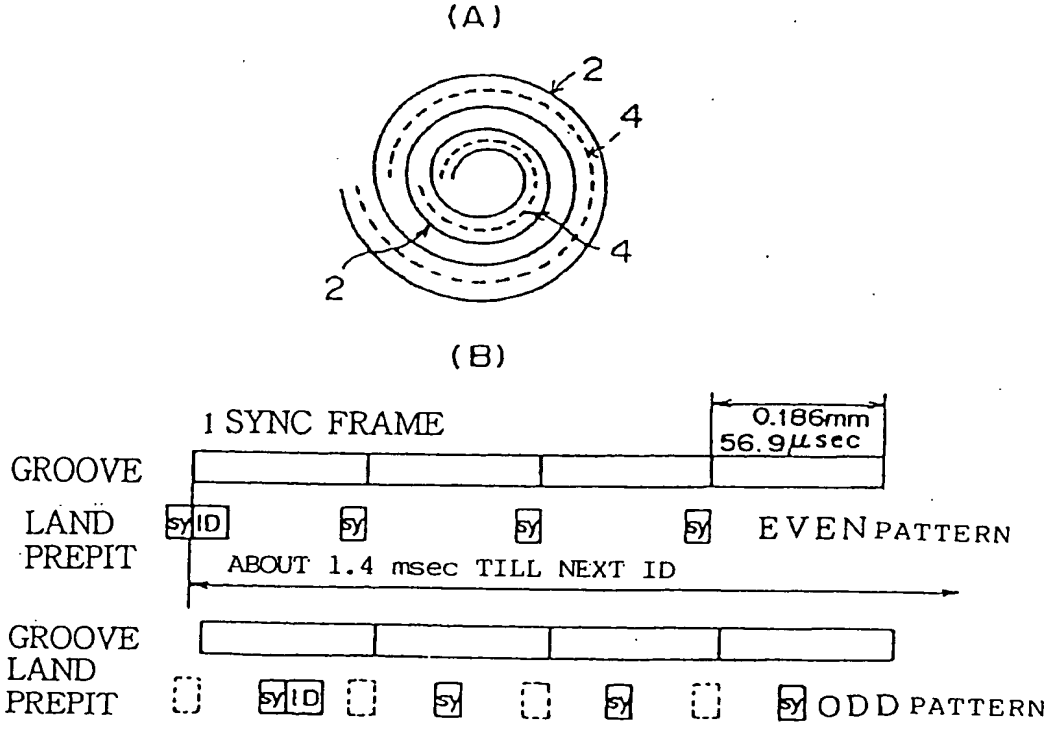


FIG.3

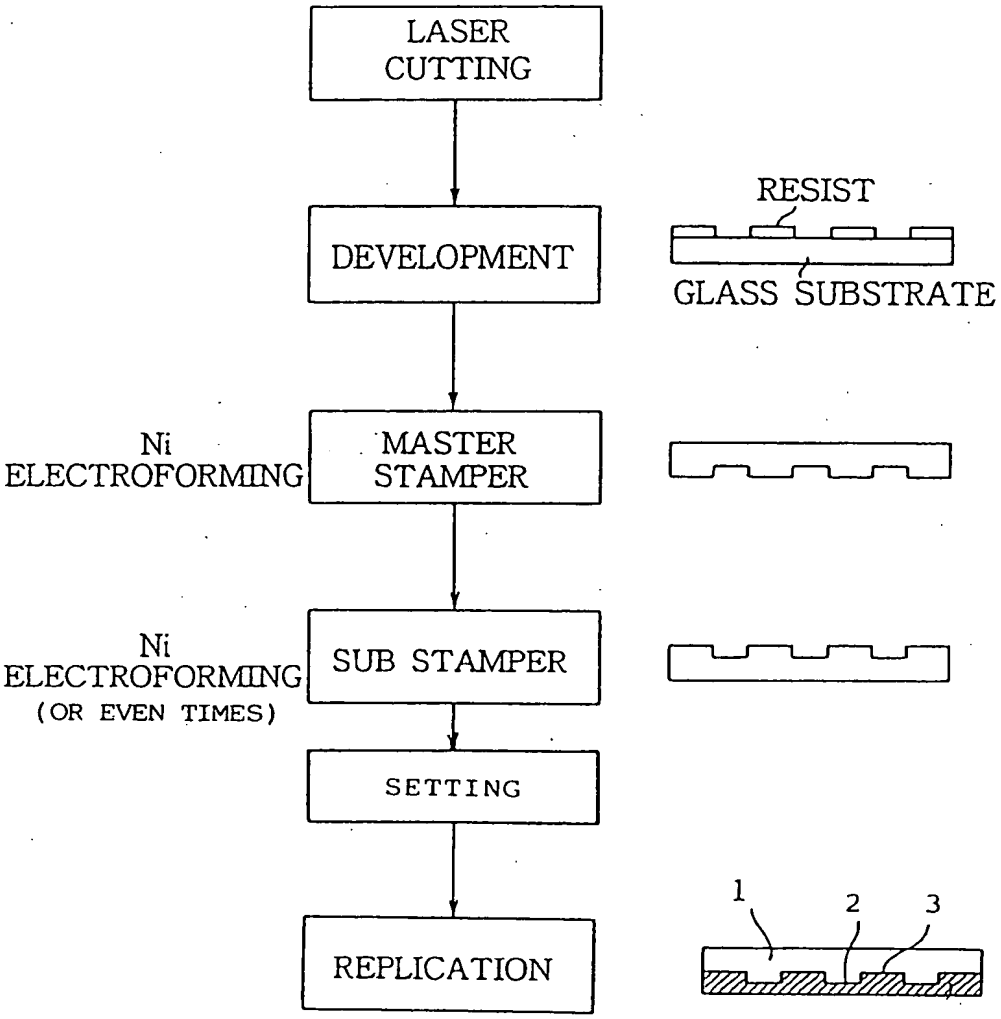

LASER CUTTING
DEVELOPMENT
RESIST
GLASS SUBSTRATE
Ni ELECTROFORMING
MASTER STAMPER
Ni ELECTROFORMING (OR EVEN TIMES)
SUB STAMPER
SETTING
REPLICATION
1
2
3

FIG.4

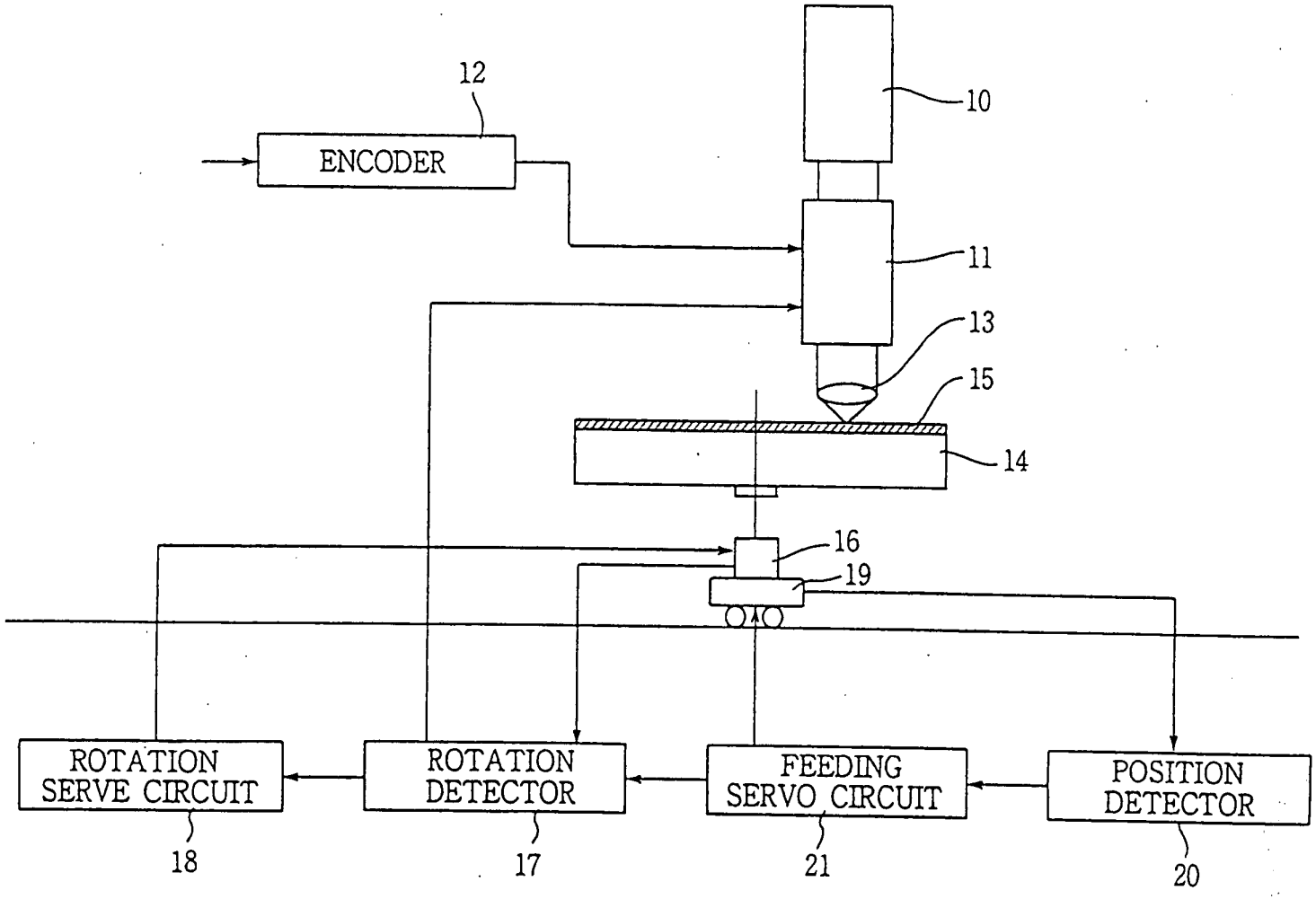

12
ENCODER
10
11
13
15
14
16
19
ROTATION SERVE CIRCUIT
ROTATION DETECTOR
FEEDING SERVO CIRCUIT
POSITION DETECTOR
18
17
21
20

FIG.5

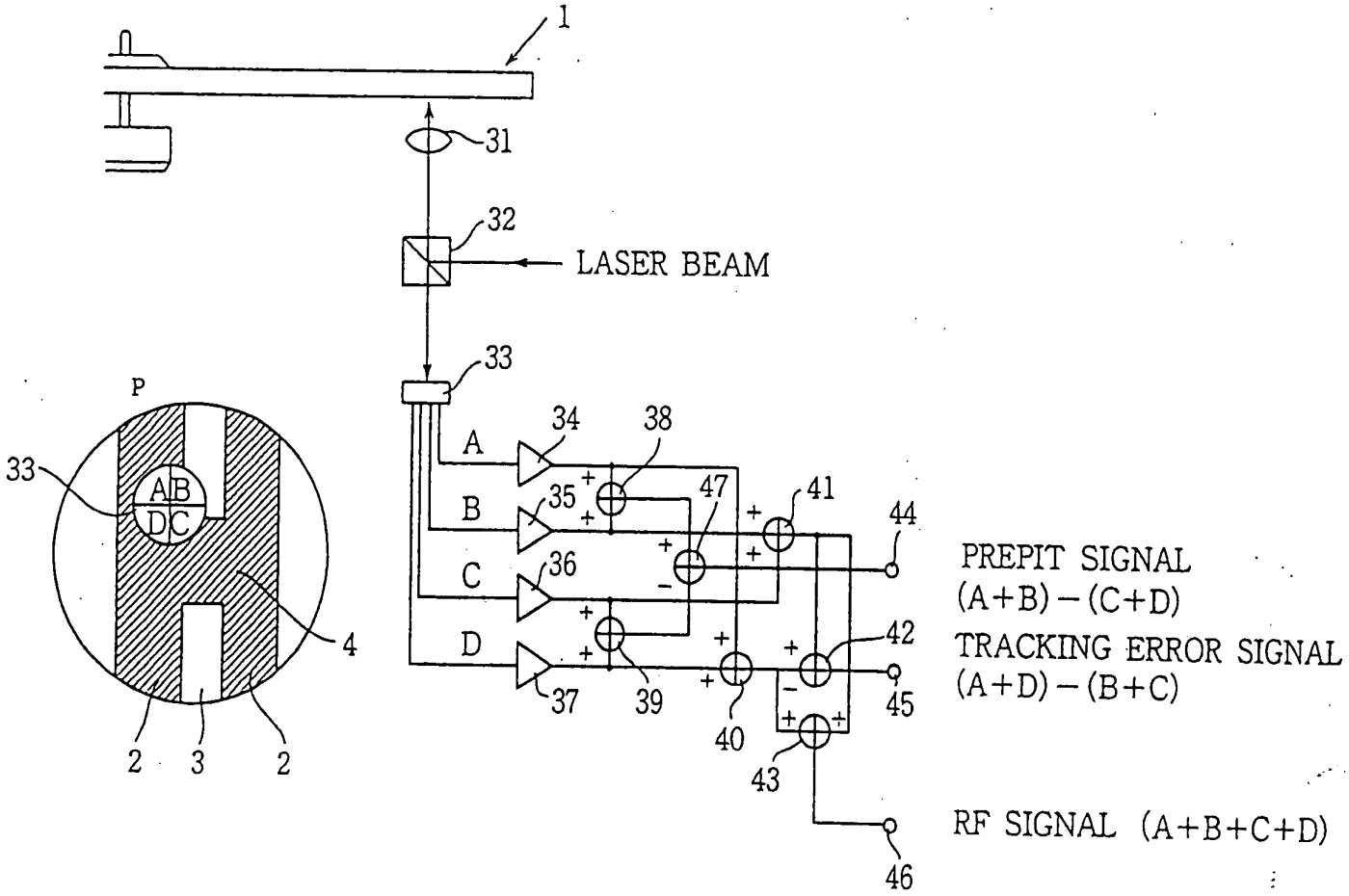

1
31
32
LASER BEAM
33
P
33
AB
DC
4
2
3
2
A
B
C
D
34
35
36
37
38
39
40
41
42
43
44
45
46
47
PREPIT SIGNAL
(A+B)−(C+D)
TRACKING ERROR SIGNAL
(A+D)−(B+C)
RF SIGNAL (A+B+C+D)

FIG.6

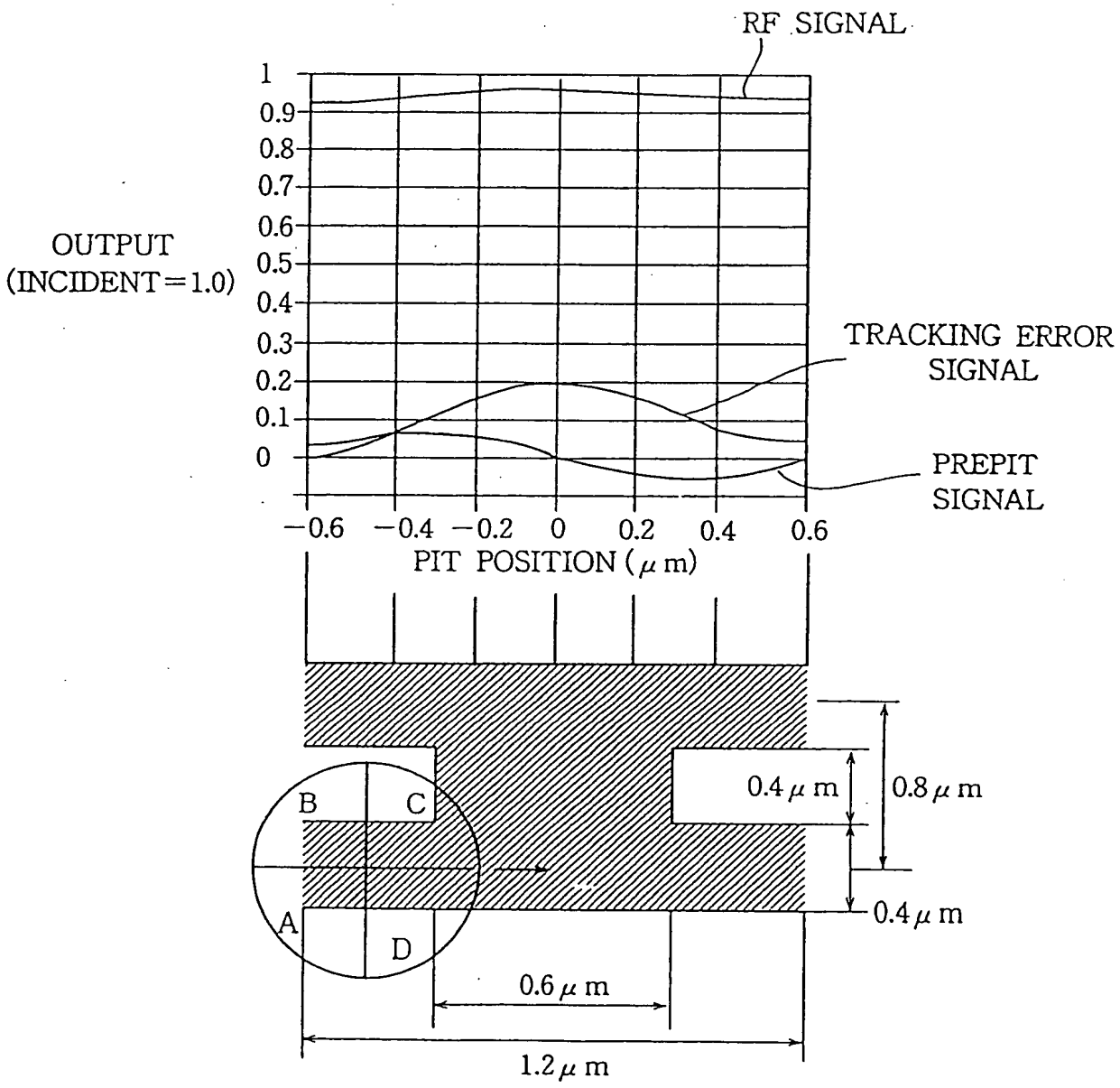

RF SIGNAL
OUTPUT
(INCIDENT=1.0)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
TRACKING ERROR
SIGNAL
PREPIT
SIGNAL
−0.6 −0.4 −0.2 0 0.2 0.4 0.6
PIT POSITION (μm)
B
C
A
D
0.4μm
0.8μm
0.4μm
0.6μm
1.2μm

FIG.7

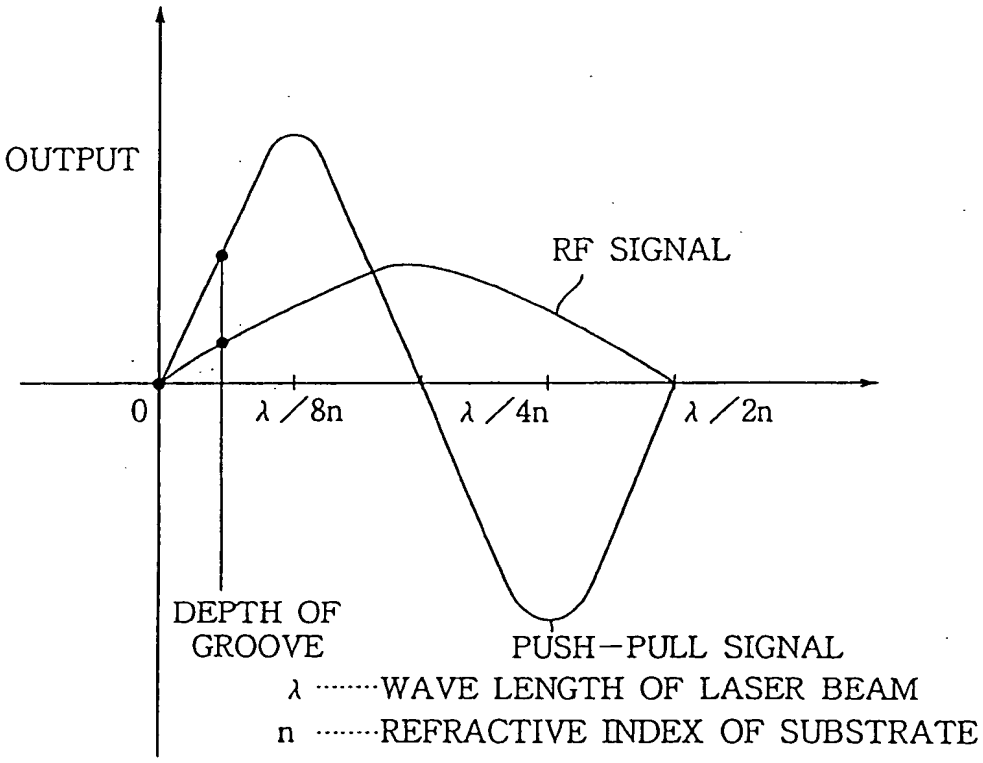

OUTPUT
RF SIGNAL
0
λ/8n
λ/4n
λ/2n
DEPTH OF GROOVE
PUSH-PULL SIGNAL
λ .....WAVE LENGTH OF LASER BEAM
n .....REFRACTIVE INDEX OF SUBSTRATE

FIG.8

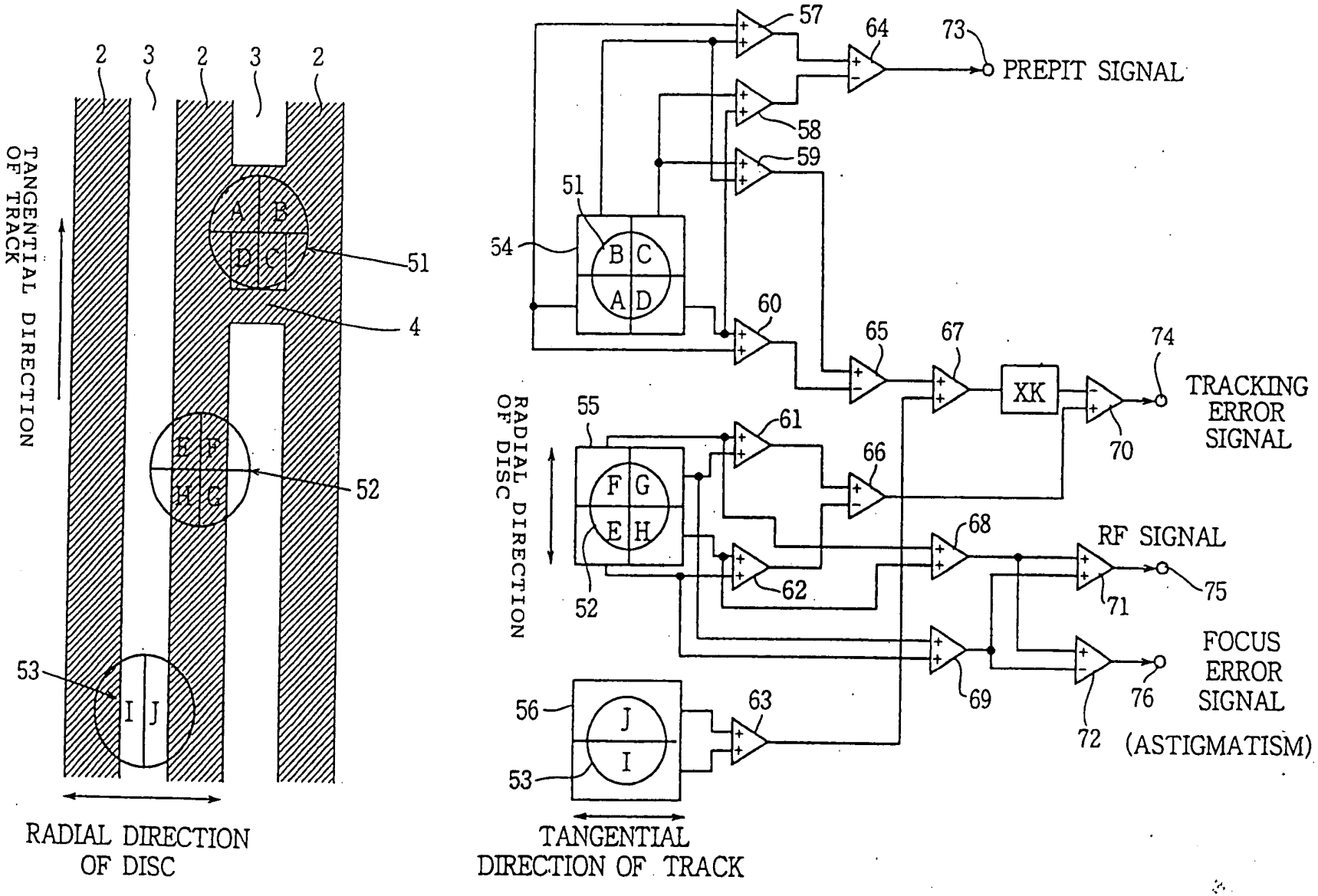
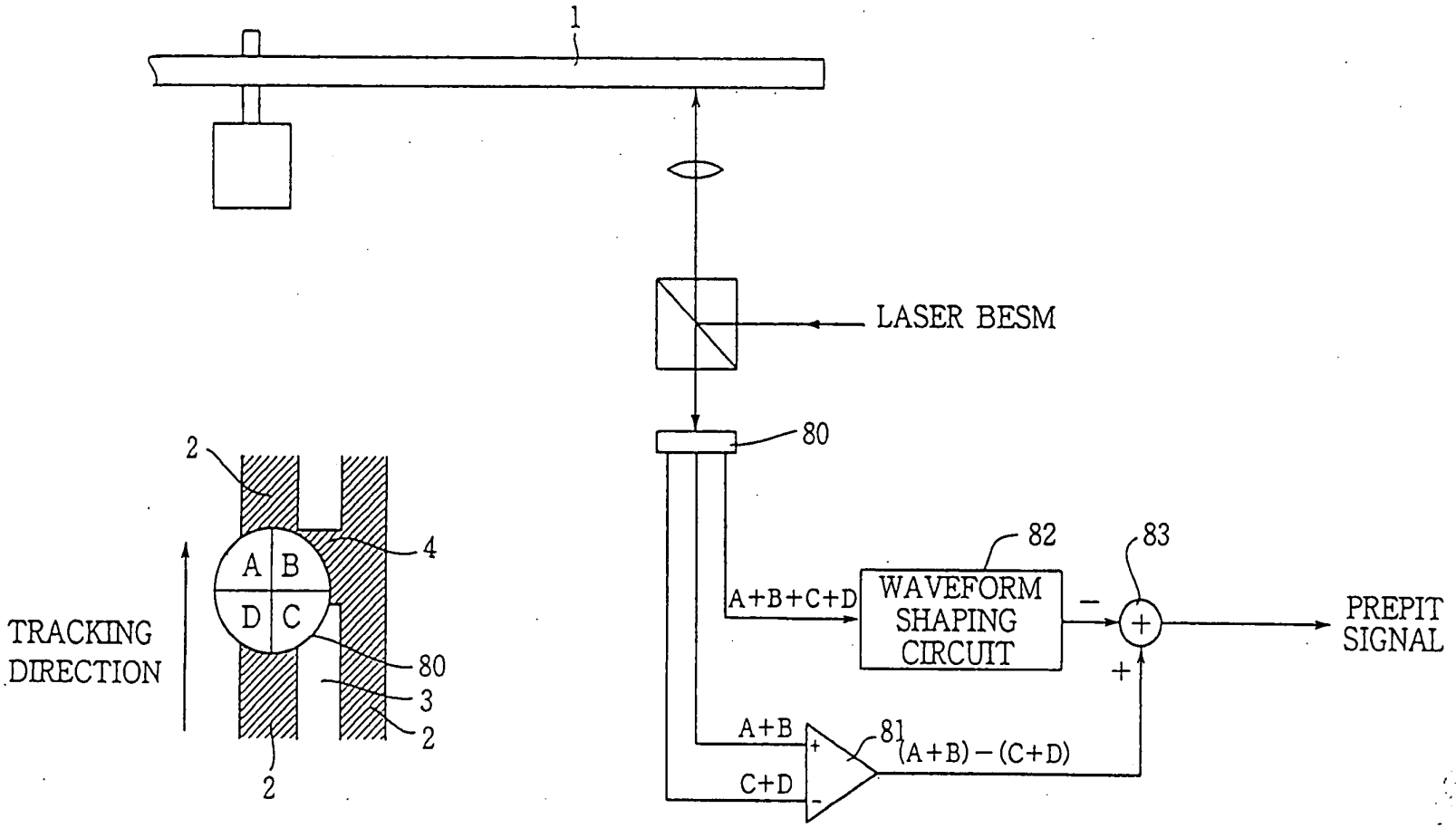

2
3
2
3
2
TANGENTIAL DIRECTION OF TRACK
A
B
D
C
51
4
E
F
H
G
52
53
I
J
RADIAL DIRECTION OF DISC
57
64
73
PREPIT SIGNAL
58
59
51
54
B
C
A
D
60
65
67
XK
74
TRACKING ERROR SIGNAL
70
55
61
66
RADIAL DIRECTION OF DISC
F
G
E
H
52
68
RF SIGNAL
62
71
75
FOCUS ERROR SIGNAL
69
76
72
(ASTIGMATISM)
56
63
J
I
53
TANGENTIAL DIRECTION OF TRACK

FIG.9


1
LASER BESM
80
2
4
A
B
D
C
TRACKING
DIRECTION
80
3
2
2
82
83
A+B+C+D
WAVEFORM
SHAPING
CIRCUIT
PREPIT
SIGNAL
A+B
C+D
81
(A+B)−(C+D)

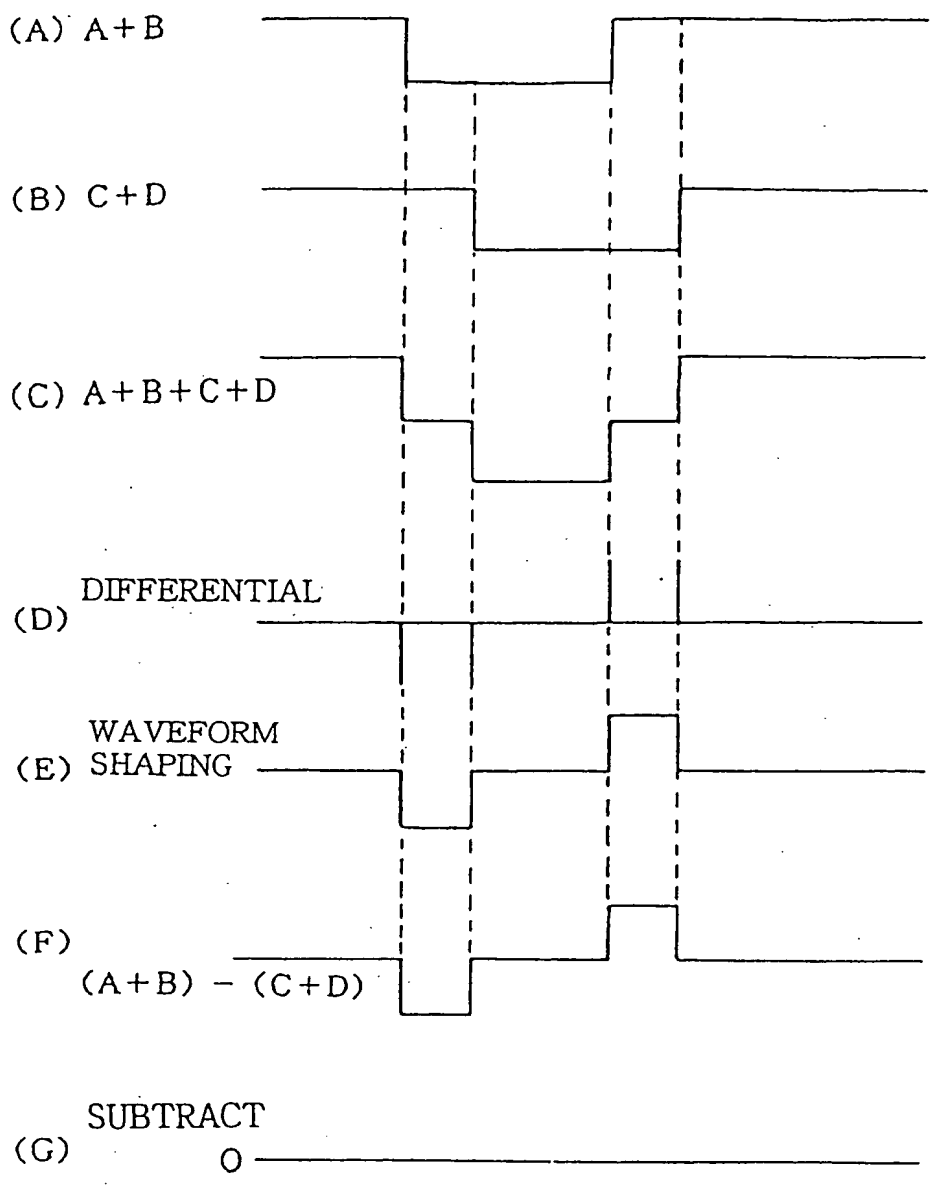

(A) A+B
(B) C+D
(C) A+B+C+D
(D) DIFFERENTIAL
(E) WAVEFORM SHAPING
(F) (A+B) − (C+D)
(G) SUBTRACT
0

FIG.10

FIG.11

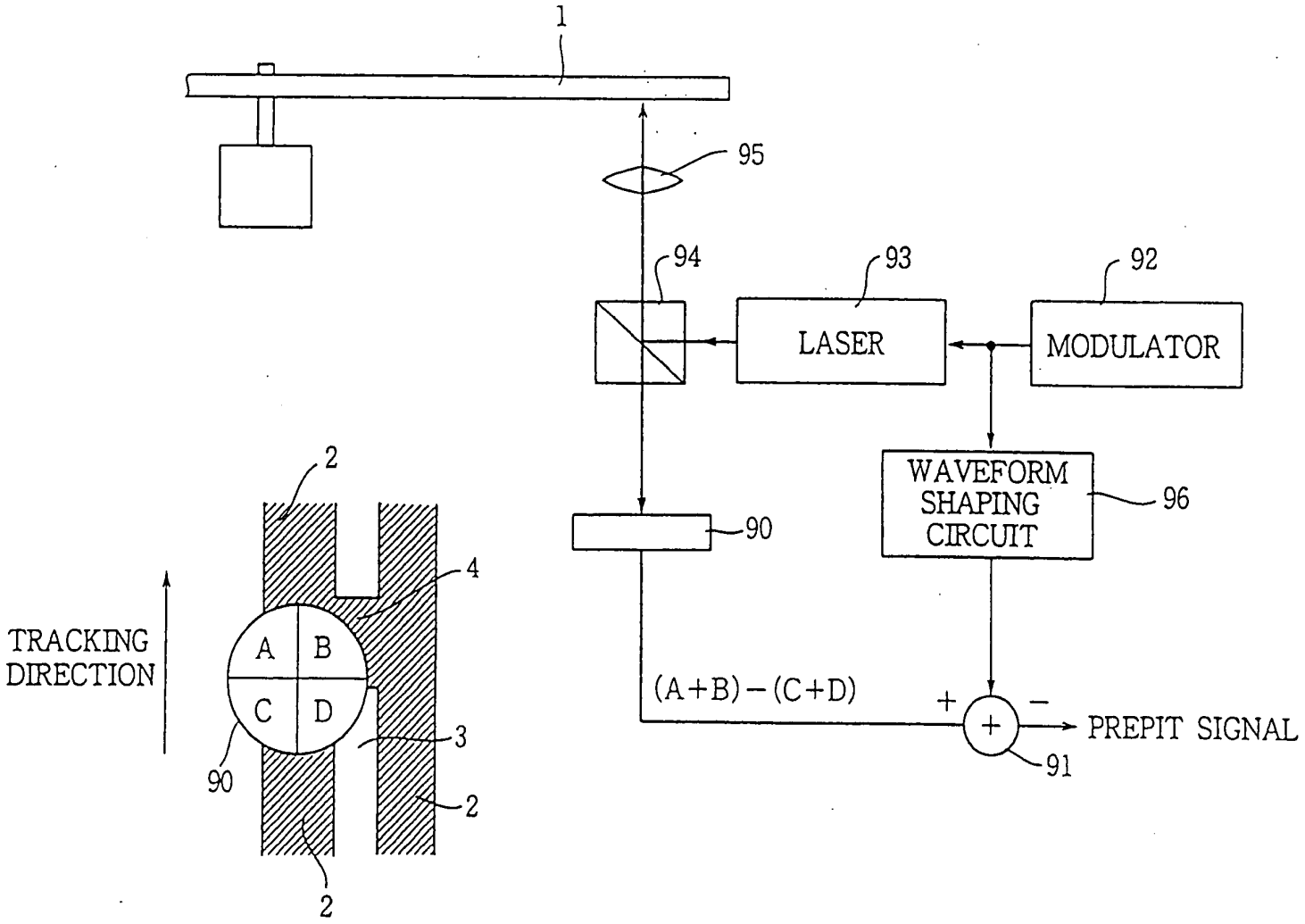
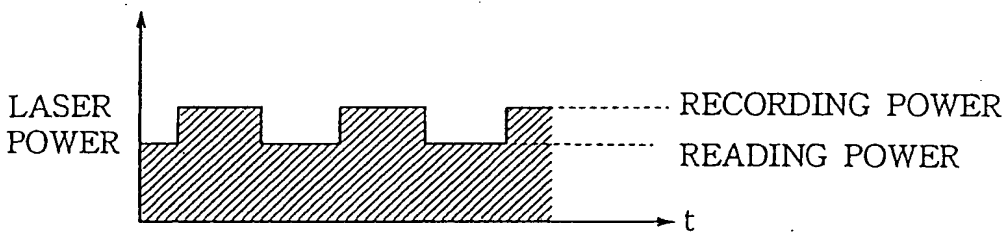

1
95
94
93
92
LASER
MODULATOR
WAVEFORM SHAPING CIRCUIT
96
90
2
4
TRACKING DIRECTION
A
B
C
D
3
90
2
2
(A+B)−(C+D)
+
−
+
PREPIT SIGNAL
91

FIG.12



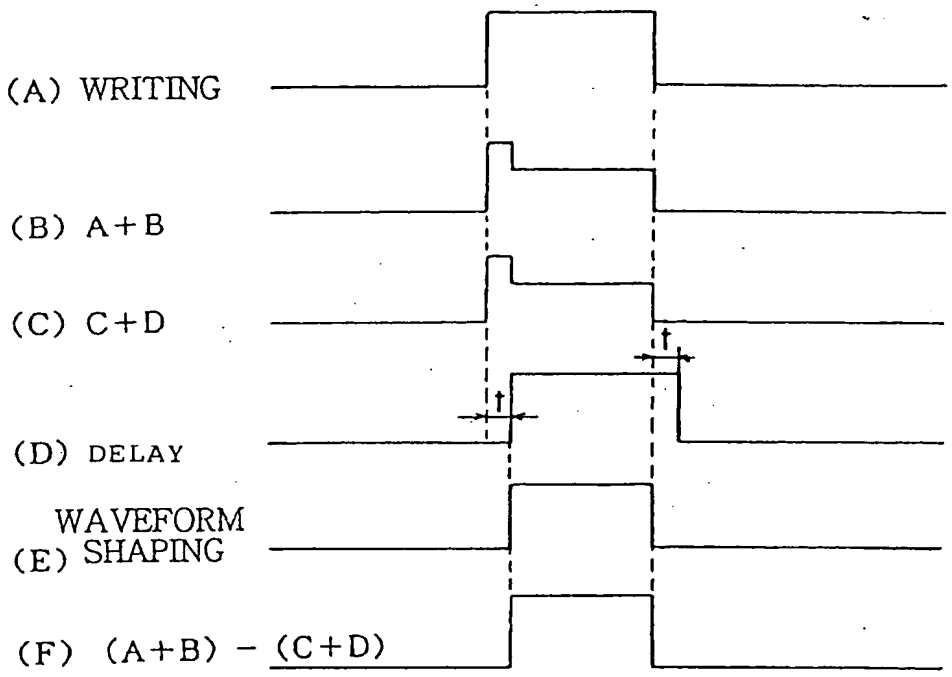


FIG.13

(Document) ABSTRACT

(Abstract)

(Object) To provide a writable optical disc in which the writing capacity of the disc is increased compared with a conventional disc, to provide a reading system of the disc, and a manufacturing method of the disc.

(Composition) A writable optical disc has an information writing track 2, and a guiding track 3 for introducing a laser beam to the information writing track. The guiding track 2 has prepit information 4 recorded thereon, the prepit information including at least address information of the optical disc. A reading system has a photodetector having two photodetecting elements divided by a line optically parallel with a radial direction of the disc for detecting reflected light of a laser beam reflected from the information writing track 2, and prepit information extracting means for extracting prepit information 4 recorded on the guiding track 3 based on a difference signal between outputs of the divided two photodetecting elements.

(Selected Drawing) Fig. 1